Section 2

• Tech & Design •

Renewable Sources of Energy

Reading Preview

Key Concepts

- What forms of energy does the sun provide?
- What are some renewable sources of energy?

Key Terms

- solar energy
- hydroelectric power
- biomass fuel
- gasohol
- geothermal energy

Target Reading Skill

Previewing Visuals Before you read, preview Figure 7. Then write two questions that you have about the diagram in a graphic organizer like the one below. As you read, answer your questions.

Solar House

Q. How does the house capture solar energy?
A.
Q.

Lab zone Discover Activity

Can You Capture Solar Energy?

1. Pour 250 milliliters of water into each of two resealable, clear plastic bags.
2. Record the water temperature in each bag. Seal the bags.
3. Put one bag in a dark or shady place. Put the other bag in a place where it will receive direct sunlight.
4. Predict what the temperature of the water in each bag will be after 30 minutes.
5. Record the temperatures after 30 minutes.

Think It Over

Developing Hypotheses How did the water temperature in each bag change? What could account for these results?

You've just arrived at the campsite for your family vacation. The sun streaming through the trees warms your face. A breeze stirs, carrying with it the smell of a campfire. Maybe you'll start your day with a dip in the warm water of a nearby hot spring.

You might be surprised to learn that even in these woods, you are surrounded by energy resources. The sun warms the air, the wind blows, and heat from inside Earth warms the waters of the spring. These sources of energy are all renewable—they are constantly being supplied. Scientists are trying to find ways to put these renewable energy resources to work to meet people's energy needs.

Campers surrounded by renewable resources ▶

Lab zone Discover Activity

Skills Focus Developing hypotheses L1

Materials 500 mL water, 2 sealable clear plastic bags, 2 thermometers

Time 10 minutes for setup; 5 minutes for follow-up

Tips Provide room-temperature water for Step 1. If your classroom does not have a sunny window, place bags in another location where there is direct sunlight.

Expected Outcome Specific temperatures will vary.

Think It Over The water temperature stayed the same in the dark/shaded bag, while the water temperature increased in the bag placed in sunlight. The water in that bag absorbed energy from the sun.

Section 2

Renewable Sources of Energy

Objectives

After completing the lesson, students will be able to

E.5.2.1 Explain the forms of energy provided by the sun.

E.5.2.2 Identify and describe various renewable sources of energy.

Target Reading Skill

Previewing Visuals Explain that looking at the visuals before they read helps students activate prior knowledge and predict what they are about to read.

Answers

Possible questions and answers include: **How does the house capture solar energy?** *(Active solar collectors on the roof, large windows on south and west sides that act as passive solar collectors)* **What does the equipment that is on the roof and in the basement do?** *(Active solar cells on the roof generate electricity that can be stored in a battery in the basement. Water heated in an active solar collector on the roof is stored in a tank in the basement and used to heat the house.)* **What is the difference between active and passive solar heating systems?** *(Both convert sunlight into thermal energy, but only active systems use pumps and fans to distribute heat.*

All in One Teaching Resources

- Transparency E43

Preteach

Build Background Knowledge L2

Identifying Alternate Energy Sources

Ask students: **What other sources of energy can you name besides coal, oil, and natural gas?** *(Answers will vary depending on students' prior learning but will likely include renewable sources covered in this section and nuclear energy covered in the next section.)*

Instruct

Harnessing the Sun's Energy

Teach Key Concepts L2

Solar Technologies

Focus Tell students that various technologies are associated with capturing solar energy.

Teach Ask: **Which approach to capturing solar energy involves the least complicated technology?** *(Passive solar heating)*

Extend Show students several examples of solar cells and small solar-powered motors, available from home-electronics stores. Ask: **What energy conversions are taking place?** *(Solar energy to electrical energy to mechanical energy)* **learning modality: kinesthetic**

Independent Practice L2

All in One Teaching Resources

- Guided Reading and Study Worksheet: *Renewable Sources of Energy*

Student Edition on Audio CD

Energy Resources

Show the Video Field Trip to let students experience the excitement of a race with cars powered by solar energy and understand the energy transformation in these cars. Discussion questions: **What are the advantages of using solar energy as an energy source?** *(It does not pollute, is inexpensive, and can be stored for later use.)*

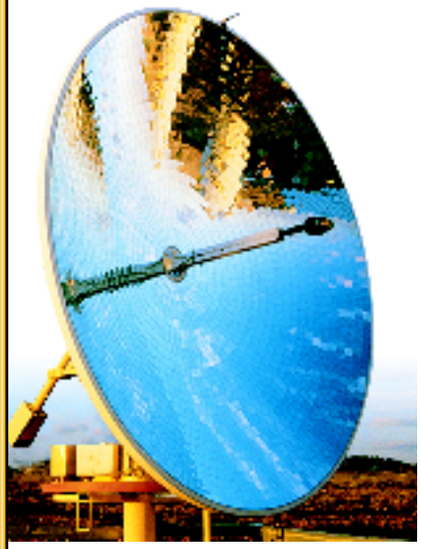


FIGURE 6
Solar Collector
This mirror collects energy from the sun and powers an electric plant in New South Wales, Australia. **Inferring** *Why is the Australian desert a practical location for a solar power plant?*

Harnessing the Sun's Energy

The warmth you feel on a sunny day is **solar energy,** or energy from the sun. **The sun constantly gives off energy in the forms of light and heat.** Solar energy is the source, directly or indirectly, of most other renewable energy resources. In one day, Earth receives enough solar energy to meet the energy needs of the entire world for 40 years. Solar energy does not cause pollution, and it will not run out for billions of years.

So why hasn't solar energy replaced energy from fossil fuels? One reason is that solar energy is only available when the sun is shining. Another problem is that the energy Earth receives from the sun is very spread out. To obtain a useful amount of power, it is necessary to collect solar energy from a large area.

Solar Power Plants One way to capture the sun's energy involves using giant mirrors. In a solar power plant, rows of mirrors focus the sun's rays to heat a tank of water. The water boils, creating steam, which can then be used to generate electricity.

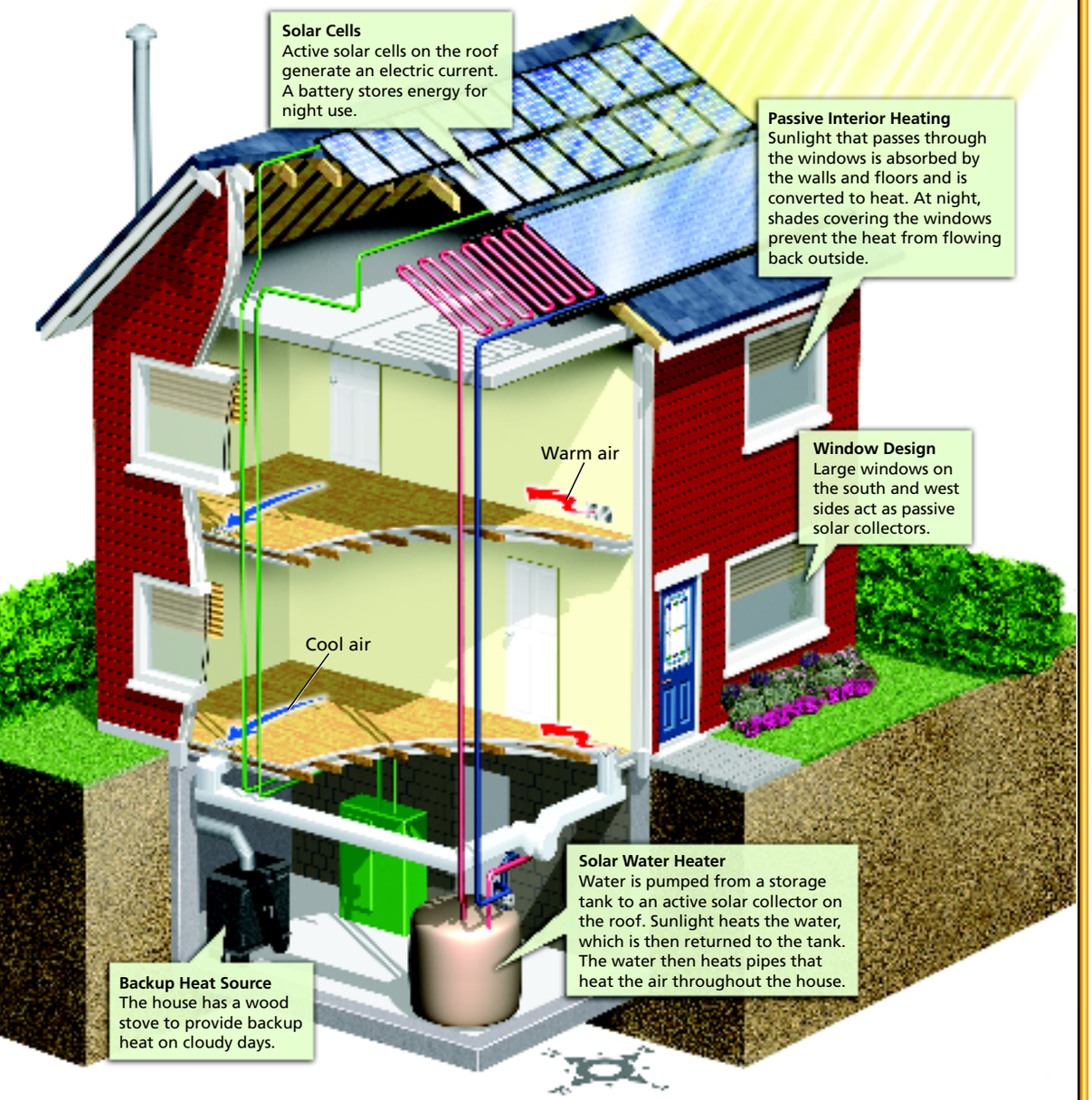
Solar Cells Solar energy can be converted directly into electricity in a solar cell. A solar cell has a negative and a positive terminal, like a battery. When light hits the cell, an electric current is produced. Solar cells power some calculators, lights, and other small devices. However, it would take more than 5,000 solar cells the size of your palm to produce enough electricity for a typical American home.

Passive Solar Heating Solar energy can be used to heat buildings with passive solar systems. A passive solar system converts sunlight into thermal energy, which is then distributed without using pumps or fans. Passive solar heating is what occurs in a parked car on a sunny day. Solar energy passes through the car's windows and heats the seats and other car parts. These parts transfer heat to the air, and the inside of the car warms. The same principle can be used to heat a home.

Active Solar Heating An active solar system captures the sun's energy, and then uses pumps and fans to distribute the heat. First, light strikes the dark metal surface of a solar collector. There, it is converted to thermal energy. Water is pumped through pipes in the solar collector to absorb the thermal energy. The heated water then flows to a storage tank. Finally, pumps and fans distribute the heat throughout the building.

Reading Checkpoint **How do solar cells work?**

FIGURE 7
Solar House
A solar house uses passive and active heating systems to convert solar energy into heat and electricity.



Use Visuals: Figure 7 L1

Exploring a Solar House

Focus Review the passive and active solar heating systems illustrated in Figure 7.

Teach Call on students to describe the various features labeled in the solar house. Ask: **Which of these solar systems do you have in your own home?** *(Most students will probably identify passive interior heating and window design.)* If any students say that their homes are equipped with active solar systems, invite those students to describe the devices and their operation to the class.

Apply Remind students that office buildings and institutions might use solar systems. Ask: **Where else in the community do you see examples of passive or active solar systems?** *(Allow a day or two for students to report examples.)* **learning modality: visual**

All in One Teaching Resources

- Transparency E44

Lab zone Build Inquiry L1

Observing Passive Solar Heating

Materials 2 thermometers, large glass jar

Time 10 minutes

Focus Tell students that they can measure the difference in temperature inside and outside a passive solar object.

Teach Take students outdoors on a sunny day away from the pavement to a spot that receives direct sunlight. Have students note the temperatures of the two thermometers. Put one thermometer in a glass jar turned upside down on the ground and leave the other thermometer in open air. Have students compare the temperatures after several minutes. Ask: **Why is the temperature higher inside the glass jar?** *(The glass allows light to pass into the jar but traps heat inside the jar.)* **learning modality: logical/mathematical**

Differentiated Instruction

Less Proficient Readers L1

Previewing Visuals Have students study Figure 7 and record at least three questions about the information in the illustration. Then have students listen to this section, Harnessing the Sun's Energy, on the *Student Edition on Audio CD*. As students listen, have them write the answers to the questions they prepared. **learning modality: verbal**

Monitor Progress L2

Oral Presentation Call on students to describe an example of technology that captures solar energy for human use.

Answers

Figure 6 The Australian desert receives intense, consistent sunlight over a large area.

Reading Checkpoint By converting solar energy into electrical energy

Hydroelectric Power

Teach Key Concepts L2

Power From Water

Focus Tell students that the water cycle plays a role in generating electricity from flowing water.

Teach Tell students that hydroelectric power depends on the controlled flow of water through tunnels (spillways or gates) in dams. Ask: **What energy conversion is taking place as flowing water turns turbines connected to a generator?** *(Mechanical energy is converted to electrical energy.)*

Apply Ask: **What are some negative effects that dams might have on the environment?** *(Possible answer: Dams can change ecosystems when they are built.)* **learning modality: logical/mathematical**

Capturing the Wind

Teach Key Concepts L2

Wind Energy

Focus Remind students that solar energy produces convection currents that produce wind for wind energy. It also provides energy for the water cycle, which is essential to hydroelectric power.

Teach Tell students that similar to the way flowing water produces electricity in a hydroelectric dam, wind generates power by moving turbines that are connected to generators. Ask: **What weather conditions are disruptive to harnessing wind energy?** *(Winds irregular; no winds; winds too strong; weather stagnant—no winds generated)* **Name two reasons why wind farms are best placed in remote locations.** *(Possible answers: Wind farms are noisy; they require a lot of space; other fuels may be difficult to transport to remote sites.)*

Apply Divide the class into two groups; assign one group water power and the other wind power. Ask: **What are the advantages of this source of electricity, and why should our community adopt it?** *(Students should consider climate and geographic restrictions, cost, potential environmental damage, and so on.)* Have each group give a brief presen-tation on its position. **learning modality: verbal**

FIGURE 8
Water and Wind Power
Both this dam in Arizona and this wind farm in California use renewable sources of energy to generate power.

Lab zone **Try This Activity**

Blowing in the Wind

You can make a model that shows how wind can do the work necessary to produce energy. Using a pinwheel and other materials, construct a device that lifts a small object when the wind blows. Then use a fan to test your device.

Making Models What parts of a wind power plant do the fan and pinwheel represent?

Hydroelectric Power

The sun is one source of renewable energy. **Other renewable sources of energy include water, the wind, biomass fuels, geothermal energy, and hydrogen.**

Solar energy is the indirect source of water power. Recall that in the water cycle, energy from the sun heats water on Earth's surface, forming water vapor. The water vapor condenses and falls back to Earth as rain and snow. As the water flows over the land, it provides another source of energy.

Hydroelectric power is electricity produced by flowing water. A dam across a river blocks the flow of water, creating a body of water called a reservoir. When a dam's floodgates are opened, water flows through tunnels at the bottom of the dam. As the water moves through the tunnels, it turns turbines, which are connected to a generator.

Today, hydroelectric power is the most widely used source of renewable energy. Unlike solar energy, flowing water provides a steady supply of energy. Once a dam and power plant are built, producing electricity is inexpensive and does not create air pollution. But hydroelectric power has limitations. In the United States, most suitable rivers have already been dammed. And dams can have negative effects on the environment.

Reading Checkpoint **What is hydroelectric power?**

Capturing the Wind

Like water power, wind energy is also an indirect form of solar energy. The sun heats Earth's surface unevenly. As a result of this uneven heating, different areas of the atmosphere have different temperatures and air pressures. The differences in pressure cause winds as air moves from one area to another.

Lab zone **Try This Activity**

Skills Focus Making models

Materials pinwheels; sticks or pencils; spools; string or monofilament; paper squares, coins, or bottle caps; tape; fans

Time 20 minutes

Tips Tell students to use simple designs.

L2 **Expected Outcome** Students should recognize that fans represent the wind; pinwheels act as windmill turbines.

Extend Compare models to actual windmills. **learning modality: kinesthetic**

Wind can be used to turn a turbine and generate electricity. Wind farms consist of many windmills. Together, the windmills generate large amounts of power.

Wind is the fastest-growing energy source in the world. Wind energy does not cause pollution. In places where fuels are difficult to transport, wind energy is the major source of power.

But wind energy has drawbacks. Few places have winds that blow steadily enough to provide much energy. Wind energy generators are noisy and can be destroyed by very strong winds. Still, as fossil fuels become more scarce, wind energy will become more important.

FIGURE 9
Biomass Fuels
Biomass fuels are fuels that are made from living things.
Comparing and Contrasting *How are biomass fuels similar to energy sources such as wind and water? How are they different?*

Biomass Fuels

Wood was probably the first fuel ever used for heat and light. Wood belongs to a group of fuels called **biomass fuels,** which are made from living things. Other biomass fuels include leaves, food wastes, and even manure. As fossil fuel supplies shrink, people are taking a closer look at biomass fuels. For example, when oil prices rose in the early 1970s, Hawaiian sugar cane farmers began burning sugar cane wastes to generate electricity. At one point, these wastes provided almost one fourth of the electricity used on the island of Kauai.

Aside from being burned as fuel, biomass materials can also be converted into other fuels. For example, corn, sugar cane, and other crops can be used to make alcohol. Adding the alcohol to gasoline forms a mixture called **gasohol.** Gasohol can be used as fuel for cars. Bacteria can produce methane gas when they decompose biomass materials in landfills. That methane can be used to heat buildings. And some crops, such as soybeans, can produce oil that can be used as fuel, which is called biodiesel fuel.

Biomass fuels are renewable resources. But it takes time for new trees to replace those that have been cut down. And producing alcohol and methane in large quantities is expensive. As a result, biomass fuels are not widely used today in the United States. But as fossil fuels become scarcer, biomass fuels may play a larger role in meeting energy needs.

Reading Checkpoint **What is gasohol?**

▲ A woman uses a wood-fired oven in Nepal.

▲ This car runs on vegetable oil.

Biomass Fuels

Teach Key Concepts L2

Fuels From Living Things

Focus Review the definition of *biomass fuels.*

Teach Explain that biomass can be burned as fuel and converted into other fuels. Ask: **Name five biomass products that can be burned as fuel.** *(Examples include: trees/wood, corn, sugar cane, landfill wastes, leaves, manure, food wastes.)*

Apply Ask: **Why do you think biomass fuels are commonly used in less developed nations?** *(They are easy to obtain and do not require special technology.)* **learning modality: verbal**

Address Misconceptions L1

New Renewables?

Focus Suggest to students that renewable energy has been around for a long time.

Teach Many people believe that renewable energy sources were developed only recently as environment-friendly alternatives to fossil fuels, but this is not the case. Ask: **What types of energy were used before people could generate electricity?** *(Burning wood, peat, other biomass fuels; wind, water)*

Apply Ask: **Why did renewable sources become less popular?** *(Energy from fossil fuels is easier to obtain, more convenient.)* **learning modality: verbal**

Monitor Progress L2

Answers

Figure 9 All derive their energy from the sun and are renewable, but biomass fuels are replenished slowly.

Reading Checkpoint Hydroelectric power is electricity produced by flowing water.

Reading Checkpoint Gasohol is car fuel that is a mixture of gasoline and an alcohol made using biomass products.

Tapping Earth's Energy

Teach Key Concepts L2

Power From Geothermal Energy

Focus Remind students that geothermal energy is the intense heat from Earth's interior.

Teach Direct students' attention to Figure 10. Ask: **How is electricity generated in a geothermal power plant?** *(Cold water piped underground is heated by magma and turns into steam, which is used to generate electricity.)*

Apply Ask: **Why isn't geothermal energy more commonly used?** *(Magma comes close to the surface only in a few areas; deep wells required in other places would be expensive.)* **learning modality: visual**

All in One Teaching Resources

- Transparency E45

The Promise of Hydrogen Power

Teach Key Concepts L2

Energy for the Future

Focus Tell students that scientists want to develop hydrogen power because of its potential to provide huge amounts of energy.

Teach Ask: **What are the advantages and disadvantages associated with hydrogen power?** *(Advantages: abundant, burns cleanly, doesn't pollute air; disadvantages: expensive to produce, almost all hydrogen is combined with oxygen in water.)*

Apply Ask: **What examples do we have of hydrogen power being supplied by fuel cells?** *(Experimental cars, space shuttle)* **learning modality: logical/mathematical**

Go Online NSTA SCILINKS

For: Links on renewable energy
Visit: www.SciLinks.org
Web Code: scn-0552

Download a worksheet that will guide students' review of Internet resources on renewable energy.

Go Online NSTA SCILINKS

For: Links on renewable energy
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Tapping Earth's Energy

Below Earth's surface are pockets of very hot liquid rock called magma. In some places, magma is very close to the surface. The intense heat from Earth's interior that warms the magma is called **geothermal energy.**

In certain regions, such as Iceland and New Zealand, magma heats underground water to the boiling point. In these places, the hot water and steam can be valuable sources of energy. For example, in Reykjavík, Iceland, 90 percent of homes are heated by water warmed underground in this way. Geothermal energy can also be used to generate electricity, as shown in Figure 10.

Geothermal energy is an unlimited source of cheap energy. But it does have disadvantages. There are only a few places where magma comes close to Earth's surface. Elsewhere, very deep wells would be needed to tap this energy. Drilling deep wells is very expensive. Even so, geothermal energy is likely to play a part in meeting energy needs in the future.

Reading Checkpoint **How can geothermal energy be used to generate electricity?**

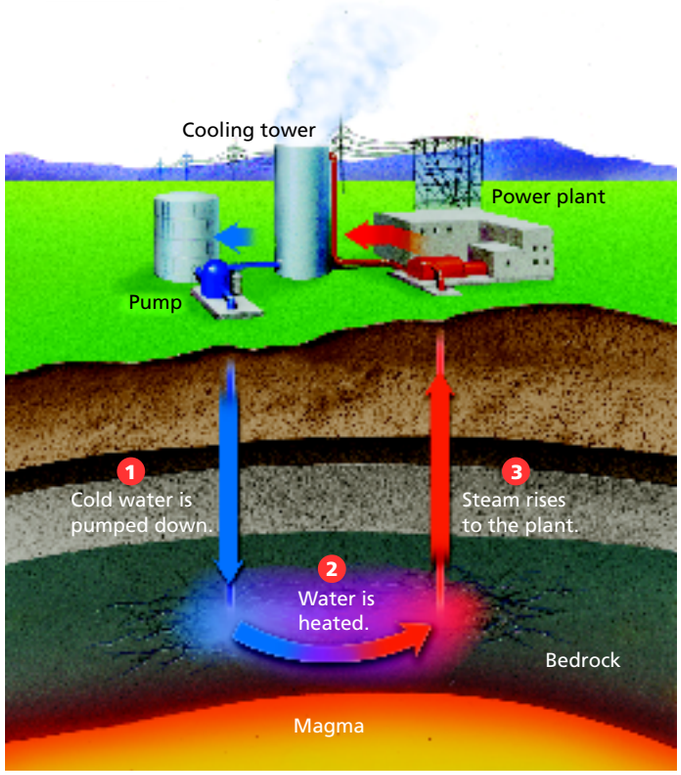


FIGURE 10
Geothermal Energy
A geothermal power plant uses heat from Earth's interior as an energy source. Cold water is piped deep into the ground, where it is heated by magma. The resulting steam can be used for heat or to generate electricity.
Making Generalizations *What is one advantage and one disadvantage of geothermal energy?*

Differentiated Instruction

Less Proficient Readers L1
Describing Geothermal Energy Have students summarize in their own words the process for generating electricity with geothermal energy. Let students share their summaries with the class in a follow-up discussion. Guide students to agree on a "best sentence" for each step in the process. **learning modality: verbal**

Gifted and Talented L3
Hydrogen Power Plants Hydrogen is the simplest of the elements and the most plentiful gas in the universe. Have students research the use of hydrogen to power electrical plants. Have them prepare diagrams to report their findings. **learning modality: logical/mathematical**

The Promise of Hydrogen Power

Now that you have read about so many energy sources, consider a fuel with this description: It burns cleanly. It creates no smog or acid rain. It exists on Earth in large supply.

This ideal-sounding fuel is real—it's hydrogen. Unfortunately, almost all the hydrogen on Earth is combined with oxygen in water. Pure hydrogen can be obtained by passing an electric current through water. But it takes more energy to obtain the hydrogen than is produced by burning it.

Still, scientists find hydrogen power promising. At present, hydroelectric plants decrease their activity when the demand for electricity is low. Instead, they could run at full capacity all the time, using the excess electricity to produce hydrogen. Similarly, solar power plants often generate more electricity than is needed during the day. This extra electricity could be used to produce hydrogen. Scientists are also searching for other ways to produce hydrogen cheaply from water.

Car manufacturers are now developing cars that run on hydrogen fuel cells. These would produce water as emissions. That water might then be used again as fuel. You can see that if scientists can find a way to produce hydrogen cheaply, it could someday be an important source of energy.

Reading Checkpoint **In what common substance is most hydrogen on Earth found?**

FIGURE 11
Hydrogen Power
The object fascinating these astronauts is a bubble of water—the harmless byproduct of the hydrogen fuel cells used on the space shuttle.

Section 2 Assessment

Target Reading Skill **Previewing Visuals** Compare your questions and answers about Figure 7 with those of a partner.

Reviewing Key Concepts

1. a. **Identifying** What two forms of energy does the sun supply?
   b. **Explaining** What are two reasons that solar energy has not replaced energy from fossil fuels?
   c. **Applying Concepts** A friend of yours argues that shopping malls should use solar energy to conserve fossil fuels. How would you respond?
2. a. **Listing** List five renewable energy sources other than solar energy.
   b. **Classifying** Which of the renewable energy sources that you listed are actually indirect forms of solar energy? Explain.
   c. **Predicting** Which source of renewable energy do you think is most likely to be used in your community in 50 years? Give reasons to support your answer.

Writing in Science

Advertisement Write an advertisement for one of the renewable energy sources discussed in this section. Be sure to mention how its advantages make it superior to the other energy sources. Also mention how scientists might be able to overcome its disadvantages.

Monitor Progress L2

Figure 10 Geothermal energy is an unlimited resource, but it comes to Earth's surface only at a few places.

Reading Checkpoint Geothermal energy heats water, creating steam that can turn a turbine.

Reading Checkpoint Most hydrogen on Earth is found in water.

Assess

Reviewing Key Concepts

1. a. heat and light **b.** only available when the sun is shining; must be collected from a very large area **c.** Students might suggest that solar energy might be used to supplement the use of fossil fuels, but should not be the only source of energy because on cloudy days not enough solar energy could be captured to provide the mall's needs.
2. a. wind, water, biomass, geothermal, hydrogen **b.** wind and water energy because water power depends on the water cycle, which is driven by the sun, and wind energy depends on the uneven heating of the Earth by the sun; biomass because the sun is needed for photosynthesis **c.** Answers will reflect students' understanding of local climate, geography, and resources.

Reteach L1

As a class, weigh the benefits and limitations of each renewable energy source.

Performance Assessment L2

Have each student create a compare/contrast table that includes at least three of the renewable energy sources discussed in this section and identifies one advantage and one disadvantage of each source. Students can save their tables in their portfolios.

Portfolio

All in One Teaching Resources

- Section Summary: *Renewable Sources of Energy*
- Review and Reinforcement: *Renewable Sources of Energy*
- Enrich: *Renewable Sources of Energy*

Lab zone Chapter Project

Keep Students on Track Provide copies of the school's fuel and utility bills so students can determine the amount and actual cost of each type of energy used. If a group is studying energy used for transportation, encourage them to survey other students about transportation to school. They also may need to contact your school district's central office or the private company that owns and operates the school buses.

Writing in Science

Writing Mode Persuasion

Scoring Rubric

4 Includes several examples; tone creative, convincing
3 Includes all criteria; tone moderately convincing
2 Includes sufficient coverage; unconvincing
1 Includes incomplete or inaccurate descriptions of both topics

Lab zone Technology Lab

Design and Build a Solar Cooker

L3

Prepare for Inquiry

Key Concept

A solar cooker that focuses the sun's rays in its center works best.

Skills Objectives

After this lab, students will be able to

- design an experiment to test how the shape of a solar cooker affects how it functions
- evaluate the effectiveness of various solar cooker designs

Prep Time 20 minutes
Class Time 40 minutes

Advance Planning

Identify a sunny area for the solar cookers.

Safety

Students should wear safety goggles and use caution in handling scissors and glass thermometers. Review the safety guidelines in Appendix A.

All in One Teaching Resources

- Lab Worksheet: *Design and Build a Solar Cooker*

Guide Inquiry

Invitation

Ask: **In what kind of places or under what conditions do you think people might cook with solar energy?** *(Accept all answers as part of the discussion; answers might include: places where the climate is hot, sunny, and dry, such as the desert; areas where electricity is not available, perhaps where people cannot afford it; places where people, such as scientists or explorers, are working under field conditions.)* **Why might the shape of a solar cooker affect how well it works?** *(The shape should influence how sunlight enters or is distributed throughout the cooker.)*

Lab zone Technology Lab
Tech & Design

Design and Build a Solar Cooker

Problem

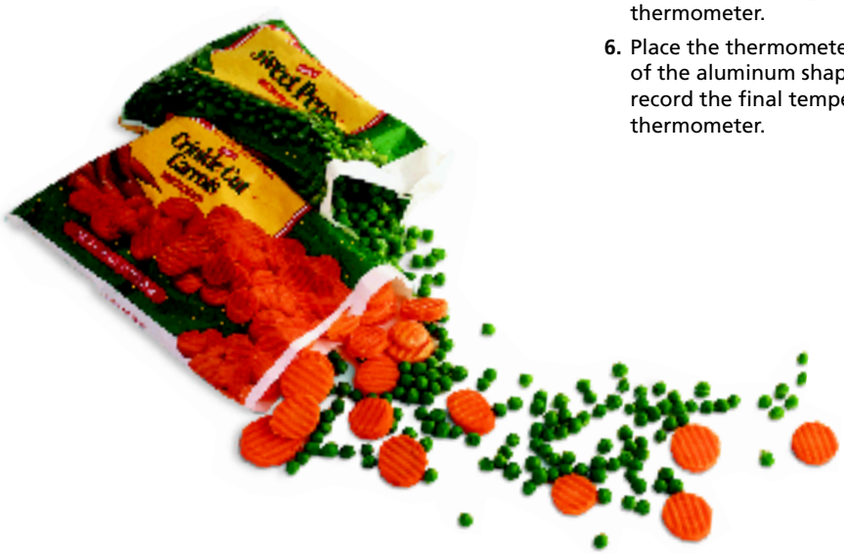
What is the best shape for a solar cooker?

Skills Focus

designing a solution, evaluating the design

Materials

- scissors
- frozen vegetables
- 3 sheets of aluminum foil
- 3 sheets of oaktag paper
- wooden or plastic stirrers
- glue
- 3 thermometers
- tape
- clock or watch
- optional materials provided by your teacher



Procedure

PART 1 Research and Investigate

1. Glue a sheet of aluminum foil, shiny side up, to each sheet of oaktag paper. Before the glue dries, gently smooth out any wrinkles in the foil.
2. Bend one sheet into a U shape. Leave another sheet flat. Bend another sheet into a shape of your own choosing.
3. Predict which shape will produce the largest temperature increase when placed in the sun. Write down your prediction and explain your reasons.
4. Place the aluminum sheets in direct sunlight. Use wood blocks or books to hold the sheets in position, if necessary.
5. Record the starting temperature on each thermometer.
6. Place the thermometer bulbs in the center of the aluminum shapes. After 15 minutes, record the final temperature on each thermometer.

Introducing the Procedure

Have students work in groups of three. Discuss sharing and rotating duties. If needed, review the meaning of *operational definition.*

Troubleshooting the Experiment

- In Step 2, make sure students have the foil on the inside of the U or inside their chosen shape.
- In Step 6, make sure students hold the thermometers with their bulbs at the same distance from the foil.

PART 2 Design and Build

7. Using what you learned in Part 1, design a solar cooker that can cook frozen vegetables. Your solar cooker should
   - be no larger than 50 cm on any side
   - cook the vegetables in less than 10 minutes
   - be made of materials approved by your teacher
8. Prepare a written description of your plan that includes a sketch of your cooker. Include a list of materials and an operational definition of a "well-cooked" vegetable. Obtain your teacher's approval for your design. Then build your solar cooker.

PART 3 Evaluate and Redesign

9. Test your solar cooker by spearing some frozen vegetables on the stirrers. Time how long it takes to cook the vegetables. Make note of any problems with your solar cooker design.
10. Based on your test, decide how you could improve the design of your cooker. Then make any desired changes to your cooker and test how the improved cooker functions.

Analyze and Conclude

1. **Identifying a Need** In what situations might it be important to have an efficient cooker that does not use fuel?
2. **Designing a Solution** How did you incorporate what you learned in Part 1 into your design in Part 2? For example, which shape did you use in your cooker design?
3. **Evaluating the Design** When you tested your solar cooker, what problems did you encounter?
4. **Redesigning** In what ways did you change your design for your second test? How did the redesign improve the performance of your cooker?
5. **Working With Design Constraints** Why might it be important for solar cookers to use inexpensive, readily available materials?
6. **Evaluating the Impact on Society** How can solar-powered devices help meet the world's future energy needs? What limitation do solar-powered devices have?

Communicate

Design an advertisement for your solar cooker that will appear in a camping magazine. Make sure your ad describes the benefits of solar cookers in general, and of your design in particular.

Expected Outcome

Specific temperatures reached will vary, but the U-shaped cooker and other curved cookers should produce the largest temperature increases, and flat cookers should produce the smallest temperature increases. Some students will have improved their cooker's performance with their redesign.

Analyze and Conclude

1. Where there are no natural resources available to use as fuel, or when individuals need to travel with a cooker (scientists, explorers, campers) and can't transport a heavy fuel source

2. Though specific situations will vary, students should have determined which shape provided the greatest change in temperature and redesigned their cookers accordingly.

3. Problems will vary with cooker shape but likely will include trouble focusing sunlight effectively and difficulties heating food evenly.

4. Redesigning likely resulted in curved (U-shaped) cookers that focus sunlight into the center and cook faster.

5. Such cookers might provide a cooking source for people who cannot afford electricity or special materials.

6. Solar-powered devices require initial construction costs but no ongoing fuel source; they can be used cheaply and designed simply enough to be transported into remote areas. They are limited by the availability of consistent sunlight.

Extend Inquiry

Communicate Be sure that students emphasize a range of features that will appeal to a range of people: initial and operating costs, ease of use, portability, sturdiness, optimal design, and so on.